Simple Model of Power Load Forecasting

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Abstract

It is very important to keep balance between electric power supply and power demand in the development of power grid because electric energy storage is still a difficult issue so far. To meet this balance, the prediction of power load is growing to a hot and crucial topic. Many models have been created for such task, including regression analysis, neural network algorithm and so on. Model of exponential weighted moving average is also a kind of method which can be used into power load forecasting. However, when considering the significant fluctuation of the power load caused by extreme weather or some political factors, hysteresis appears in this model. To correct the error in the predictive values along with the hysteresis, a coefficient which is the ratio of the data in recent days to those historical contemporaneous data can be added to the predictive values. The acquisition of the coefficient also follows the rule in model of exponential weighted moving average, which is that the more recent data make sense.

Keywords

Power load forecasting, Model of exponential weighted moving average.

1. Introduction

Supply of electric power is a crucial guarantee of national economic development. Because of the unique nature of such power, that is, it can not be stored in large quantities, electric power need to be generated, transmitted, distributed and consumed at the same time, thus forming the whole inseparable power grid. As a result, in order to achieve higher benefits, people should have a full understanding of the power load to determine how much electric power to generate. On the other hand, the emergence of brand new industry and modern life style makes the power load more uncertain, in which case, accurate prediction of power load becomes a hot research topic. Besides, the change of climate and policy orientation also have a great impact on power load. Model of exponential weighted moving average is a method which uses the historical contemporaneous data to give predictions. The weight is determined according to the time difference, which means earlier data have less weight for their lower reference value.

2. Model of exponential weighted moving average (EWMA)

In load forecasting, the EWMA model is always written as:

$$Z_t = \beta x_{t-1} + (1-\beta) Z_{t-1} \tag{1}$$

Z_t is the EWMA predictive value on the present, Z_{t-1} is the predictive value a moment before, and x_{t-1} means the actual value a moment before. The weight coefficient β is between 0 and 1. The larger coefficient means that the historical information is less considered, while the prediction information largely comes from the previous moment, which is applied to the case of large data fluctuation. On the contrary, when the coefficient is small enough, the prediction information is more focused on historical information, which is suitable for the situation that the data is relatively stable.

From the recurrence relation, we find the expression of Z_t is:

$$Z_t = \beta x_{t-1} + \beta(1-\beta)x_{t-2} + ... + \beta(1-\beta)^{t-1}x_0 + (1-\beta)^t Z_0 \quad (2)$$

Z_0 is the initial value.

We can easily find that the weight decreases exponentially when the time becomes earlier.

As the number of recursion increases, the relationship between the predictive value and the initial value gets smaller. If we set the initial value to 0, the early result may be a little small, but on later stage there is tiny differences. We can also set the initial value to the actual value at the beginning.

3. Application in power load forecasting

Through EWMA model, we can use the contemporaneous data of previous years to forecast the power load of a certain day in the current year.

Let $Z_{t,p}$ be the predictive value on the pth day in the tth year， $x_{t,p}$ be the regarding actual load, we could get:

$$Z_{t,p} = \beta x_{t-1,p} + (1-\beta)Z_{t-1,p} \quad (3)$$

However, this kind of forecasting method is more applicable for the situation that the power load has little fluctuation and probably changes around a certain value. With the development of social economy, the consumption of electric power in industrial production and daily life is constantly improving. If the power load grows steadily, though we set a large weight coefficient β, hysteresis will still appear in the values predicted by using the historical data. At the same time, some extreme climate or abnormal weather, such as extremely hot summer and warm winter, also result in a sharp climb or drop of power load, affecting the forecast.

To simplify the situation, we use series of idea data with the same shape which increase steadily to represent the power load symbolically.

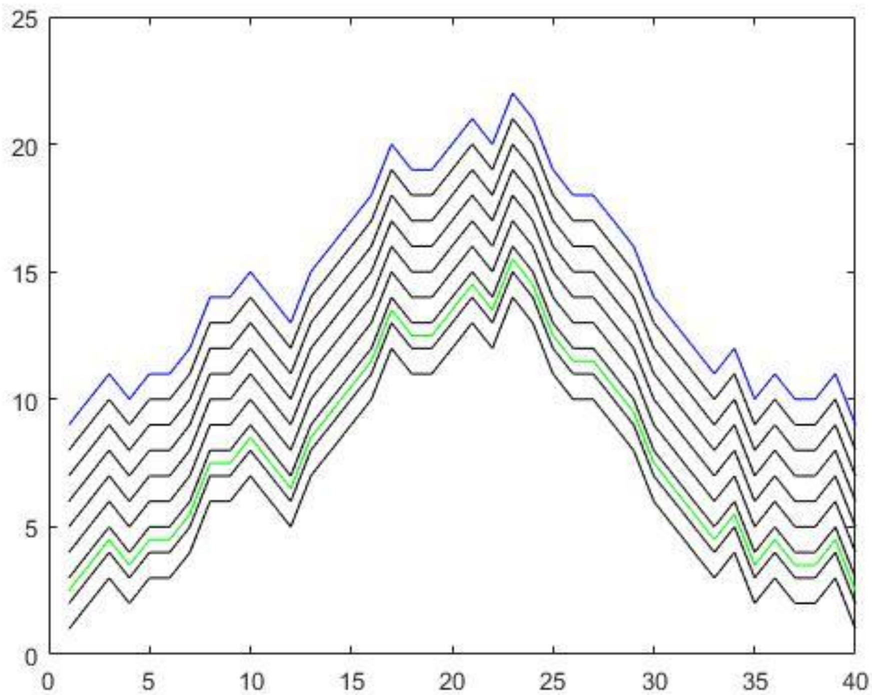

Figure 1. Idea annual power load

The black line represents the annual-increasing electric power load, blue line means power load reached to its peak in the penultimate year, while the green one describes a dramatic drop of power load due to extreme climate or some political factors in the last year.

Now we forecast the load value by using EWMA model and make a comparison between predictive value and the actual value.

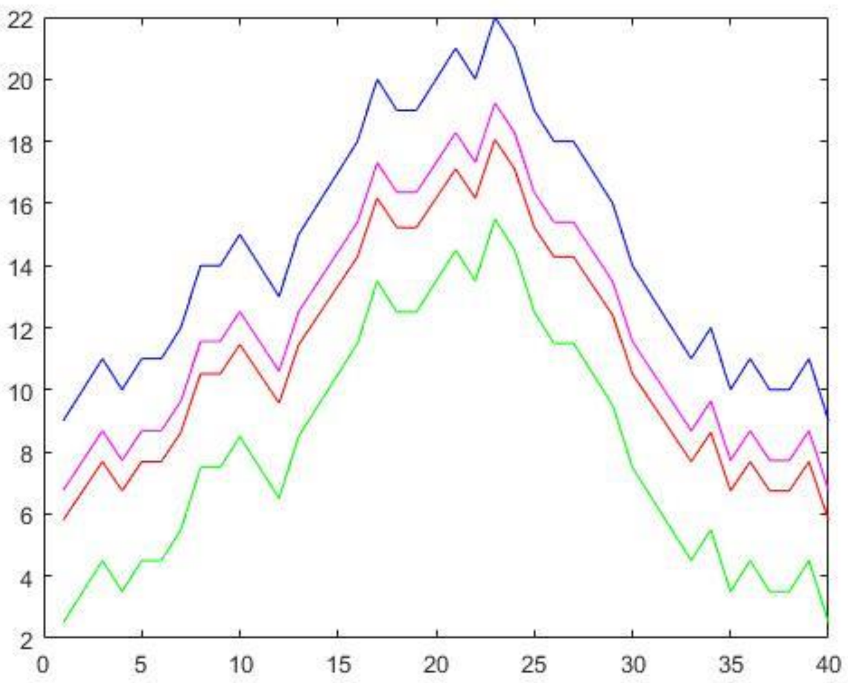

Figure 2. Forecast by EWMA model

The red line in the figure shows the forecast data of the load in the penultimate year, while the purple line is the forecast of the power load in the last year. We can see that since the load is increasing every year, the load forecast in the penultimate year is obviously lower than the actual value, and the predictive value is much larger than the actual value due to the sudden drop of load in the last year.

4. Introduce the ratio of the actual value to the historical contemporaneous data to correct the forecast results

Electric power load always fluctuate around a certain value in a short period of days, no matter the extra effect comes from abnormal weather or policy orientation. For example, the ratio of the power load during a continual week to their contemporaneous data changes little. Therefore, we can introduce a correction factor k, which is the ratio of the actual load in past days to the regarding historical contemporaneous information, to correct the forecast data. By adding such correction factor, we can reduce the error when the power load in current year or current period of time are generally higher or lower than previous years.

The acquisition of the correction factor k follows the same rule in model of exponential weighted moving average and more recent data contributes more information to the forecast. If the power load changed in the same tendency smoothly in the past years, we can obtain the correction factor by averaging the ratio of the load of the past few days to that of the same period of last year according to different weights. That is:

$$\mathrm{k} = \alpha \frac{x_{t,p-1}}{x_{t-1,p-1}} + \alpha^2 \frac{x_{t,p-2}}{x_{t-1,p-2}} + \ldots + \alpha^n \frac{x_{t,p-n}}{x_{t-1,p-n}} \tag{4}$$

α is a weight coefficient also between 0 and 1 which decrease exponentially when the time of reference data becomes earlier. It means if the data is too early, considering the severe fluctuation in just a few days, there would be more differences between the regarding ratio and that of today's. As a result, the reliability would be greatly reduced.

Also, the specific value of α is related to how many days in the past we take into consideration. If the number of the days we take as a reference is n, normally we set:

$$\sum_{i=1}^{n} \alpha^{i} \approx 1 \quad (5)$$

Bring this simple correction effect into previous idea data. The predictive values of the first four numbers are obtained according to the prediction method without correction, and the later values are multiplied by the correction coefficient. The correction coefficient k is the weighted average of the ratio of the load in past four days to the contemporaneous data in last year.

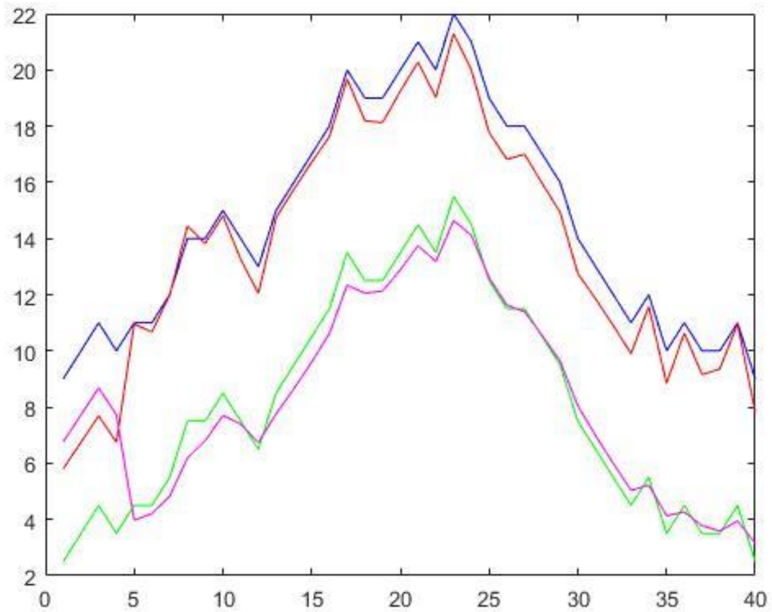

Figure 3. Forecast after correction

It is obvious that in the first four days, there is a big difference between the EWMA predictive value and the actual value, and the predictive value rapidly approach the actual value after the correction factor been introduced.

5. Conclusion

Load forecasting is very important in the development of modern electric power. The model of exponential weighted moving average can forecast the current power load by referring to the data of the same period in previous years. But on the other hand, some special circumstances including extreme weather and policy change may lead to a generally rise or drop, or even a sudden change, of power load, affecting the reliability of forecast. We try to compare the recent actual data with the corresponding data in last year and introduce a correction factor to adjust the predictive value.

Two shortcomings would be found in this method.:

At first, the correction factor is only suitable for the situation that the weight coefficient β in EWMA model is small because we obtain the factor only by using the information in last year, which means if β is large, the predictive value is closed related to overall information in history rather than last year's, in which case there will be great error in the forecast value when last year is a year of extreme weather. To overcome this problem, we can change the computing method of correction factor k to make it more related to the load data in history (more than last year).

Besides, the effect of correction is only verified by the change of the assumed ideal data in this paper. The actual power load curve is much more complex, and many other factors need to be considered in practical application.

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